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1 12. Side Channel / Off Channel Habitat

1.1 Introduction

1.1.1 Description of Technique

Definition of Side Channel Habitat

In unrestricted natural river systems, side channel habitat is constantly created and abandoned as the river migrates laterally and changes course. Naturally formed side channel habitat is usually associated with former stream channels abandoned through natural process, or the landward side of gravel bars formed during high flow events within the active channel area. Unfortunately, restrictions and constraints such as levees, dikes, and berms imposed on the system do not allow for natural channel meandering and result in a reduced ability to create new side channels and subsequent loss of this valuable habitat.

Side channels often derive a major portion of their flow from either groundwater or seepage from the adjacent stream/river. The role of surface water in side channel habitats is variable depending on hydrology, channel topography, and physical features. Many of the side channels used extensively by salmonids are protected from extreme high flows by buildup of gravel or a log jam at the upstream end.

Peterson and Reid (date) describe three types of habitat within a river floodplain: overflow channels, percolation-fed channels and wall-based channels (Figure).[2] Overflow channels are very active and prone to frequent flooding. Percolation channels are protected somewhat from flood flows and have the benefit of providing winter and summer refuge for juvenile fish and spawning habitat for adult fish. Wall-based channels often sit high in the river floodplain and are protected from flood flows and have been developed mainly as overwintering habitat for juvenile coho and trout.

Value of Side Channel Habitats

Side channel habitat is valuable aquatic, wetland type habitat that benefits a variety of aquatic and terrestrial species and includes both spring flowing channels and backwater wetlands. Side channel wetlands and ponds have been found to provide critical habitats for both juvenile salmonids (Peterson 1982; Cederholm and Scarlett 1982) and a variety of wildlife species (Zarnowitz and Raedeke 1984). Species that frequent these areas and the attendant riparian community include amphibians, reptiles, birds, mammals, and mollusks (FEMAT 1993). Side channels may function as spawning, rearing, and overwintering habitat for fish as well as providing a refuge from floods. In many larger river systems, side channels are important spawning areas, particularly for chum and coho salmon. They are also recognized for their value as summer and winter rearing habitat for coho salmon and cutthroat trout. Under most circumstances, a side channel provides more stable flow and temperature regimes that the main channel.

Creating/Restoring/Enhancing Side Channel and Off Channel Habitats

The following text discusses both the enhancement and restoration existing side channel habitats and the creation of new habitat in suitable off-channel areas. The creation of new habitat focuses on primarily on the creation of artificial spawning channels.

Enhancement / Restoration of Existing Side Channel Habitat

Since 1980, habitat enhancement programs in British Columbia and Washington State have given serious attention to the development of off-channel spawning and rearing habitat, primarily to benefit salmon.[1] Projects have included restoration and modifications to river floodplain swales, abandoned side channels, and floodplain channels along steep terrace bluffs, all in order to increase spawning and rearing habitat. Many of these projects rely on providing a mechanism for the introduction of additional ground and/or surfacewater to provide the desired fisheries benefit.

Creation of New Off-Channel Habitat

Artificial (man-made) spawning channels have been advanced as an alternative to the use of hatcheries. Spawning channel projects typically require intense manipulation of the physical and hydraulic environment to provide suitable conditions. Spawning channels have developed for the production of chinook, sockeye, pink, and chum salmon. When properly designed and constructed, spawning channels permit a greater percolation rate and thus a higher egg to fry survival rate than observed in natural streambeds (Bell, 1991).

Placeholder – talk about newly created channels, rearing ponds

1.1.2 Physical and Biological Effects

Physical Effects

Restored/Enhanced

The transport of sediment in side channel habitats has direct effect on project success and longevity. Side channels that infrequently experience high flows may fill in with fine sediment over time. The presence of backwater in side channel habitat may constrain its ability to flush fine sediment.

Conversely, large flow events that reach the side channel can headcut through to the river mainstem and encourage avulsions.

On larger projects, an excavated channel can affect the local groundwater level. As such, there is a potential that wetlands can be drained and vegetation characteristics of the floodplain can be affected.

Created

A created artificial spawning channel or rearing pond has the potential to disrupt groundwater flow to the detriment of adjacent aquatic and terrestrial resources.

Biological Effects

Restored/Enhanced

A carefully designed channel enhancement project can provide both spawning and rearing habitats depending on physical conditions and hydrology. The quantity and quality of side channel habitat depends on the frequency, magnitude, and duration of flow delivered to these areas. A channel that is fed primarily by groundwater flow provides a more stable environment for incubation and rearing than does a channel that relies solely on surface flow. During floods, side channels frequently offer refuge from mainstem conditions. Flow conditions and water temperatures are more consistent and predictable in channels fed by groundwater. Furthermore, groundwater-fed channels run warmer and clearer in the winter, providing better prey production and feeding opportunities, and a less harsh overwintering habitat. Use is dependent on connectivity (access) between mainstem and side channel habitat and the presence of suitable habitat characteristics. Habitats may be available intermittently or only seasonally.

Intermittently watered habitats may suffer from poor water quality. Backwatered channels may be prone to excess sedimentation reducing their utility for spawning as fines fill the interstitial spaces. However, natural side channels may experience regular flooding and redistribution of gravels, flushing of fines when side channel becomes inundated. These floods may be beneficial or they can potentially alter habitat conditions, scour the streambed and physically destroy incubating eggs.

Created

With the use of created spawning channels, productivity can be enhanced through the “controlled” spawning environment. In some cases, the channel can be located to be protected from frequent flooding thereby improving its utility. However, the absence of “flushing” flows can impact the longevity of the project and cleaning of the substrate may be required.

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1.1.3 Application of Technique

Side channel and off-channel spawning and rearing areas are intended as mitigation for other projects that confine a channel (e.g.; bank protection, bridges) and as habitat restoration. Enhancement and restoration of existing side channel habitat and construction of off-channel spawning and rearing habitat may provide mitigation for the future loss of this habitat type, or lost opportunity.

1.1.3.1 Enhancement / Restoration of Side Channels

Side channels often derive a major portion of their flow from either groundwater or seepage from the adjacent stream/river. Many abandoned natural channels exhibit year-round flow from groundwater or springs. The quantity and quality of side channel habitat depends on the volume and timing of groundwater and/or surface water flow delivered to these areas. The primary objective in enhancing or restoring a groundwater or spring-fed channels is optimize the conditions necessary to provide habitat for spawning and/or rearing. The type of side channel (overflow, percolation-fed, or wall-based) has direct bearing on the approach to the project and potential fisheries benefits.

Overflow channels are flood swales that are directly connected to the main river channel during high flows. Fish habitat associated with overflow channels is often unstable and typically prone to flooding and channel shifting. On the other hand, periodic floods through these channels can help maintain their productivity.

Percolation-fed channels, "perc channels," are relict river and/or flood channels and are supplied by water that percolates as local groundwater from the river. Frequently, they are better protected from floods than overflow channels and can provide ideal sites for spawning habitat enhancement and also provide winter and summer refuge for juvenile fish.

Wall-based channels can be groundwater fed but are often fed from springs or surface water from the adjacent terrace. They are usually higher in elevation relative to percolation-fed channels. Wall based-channels can often be enhanced to provide excellent rearing and overwintering habitat for certain species of juvenile salmonids.

This technique may be applied in a manner that simply improves the spatial or temporal availability of flow or integrated with habitat modifications such as rearing ponds or spawning pads to maximize fisheries benefits. Side channels provide a unique opportunity to restore and enhance riverine and floodplain environments. The connectivity between mainstem and side channel habitat enhances fisheries benefits by providing habitat diversity.

Placeholder: briefly mention the grey area in definition of "groundwater" and hyporheic flow, *particularly in abandoned historic channels or "perc" flow channels. Refer to Hydrology appendix for further discussion of hyporheic flow.*

1.1.3.2 Created Off-Channel Habitats

Groundwater and spring-fed channels have year-round flow from springs or groundwater and may exist naturally, or may be created. The primary objective in establishing a groundwater or spring-fed channel or rearing pond is to provide habitat for spawning and/or rearing. The proportion of the site used to meet a particular life history requirement can vary. It is site- and species-specific and should be based on mitigation requirements or limiting factors to fish production in the watershed, and target species of fish. Some sites are allocated and designed solely to function as spawning sites, whereas other sites may incorporate juvenile rearing and adult holding habitat into the design. Numerous variations are possible with this type of project relative to site conditions and biological considerations.

Although not a process-based restoration activity, artificial spawning channels have been used in many rivers in the Pacific Northwest to increase recruitment by augmenting available spawning area. Most spawning channels have been constructed for anadromous salmonid production. Many of these have been successful and in continuous operation for over 20 years while others have been plagued with problems including sedimentation and poor water quality, or have simply failed to attract the target species.

Placeholder: created side-channel habitat may be either constructed anew by excavation, or it may be created by connecting and enhancing existing flow paths such as floodplain swales, ditches, or other depressions. The common feature of all of these is the creation of environments that exhibit flowing water, spawning habitat, and are connected to stream systems with spawning populations.

Placeholder: discuss why should this type of technique be considered and under what circumstances.

In general, there are two types of artificial channels created for spawning; upwelling and stream (Bell, 1991). The upwelling channels rely on either natural groundwater recharge and percolation up through the gravels, or on artificially induced upwelling via subsurface flow introduction. These channels are generally used by salmonids, which actively seek upwelling currents for spawning (sockeye, kokanee, pink, chum, and to a lesser extent, coho salmon). Other species such as chinook salmon prefer the stream type channel, which relies on surface flow without upwelling. Spawning channels are constructed to provide near optimum conditions for spawning and incubation. This includes optimum gravel sizes, water velocities and depths which promote utilization by the target species and high egg to fry survival rates.

1.2 Scale

Side channel habitat exists in nature on virtually all sizes of alluvial river and can be thousands of feet in length, for example when a large river shifts location and abandons its previous channel. Restoration and enhancement projects can be implemented at specific sites along a side channel, or continuously along the length of a channel. The scale of projects implemented within a channel depends on the objectives of the project and available resources.

1.3 Risk and Uncertainty

Risks to habitat associated with this technique are low primarily because the work is done out of the main river channel and often in what is initially an upland area. There are risks of beavers changing the channel control elevation and the channel or pond becoming contaminated with sediment. There is a risk of stranding fish if elevations and flows are not accurately estimated, and surface flow is lost from portions of the project. Over time, leafy material from trees and fine sediment may accumulate and limit productivity or fish passage. These processes are usually part of the natural evolution of side channels. The intent for this type of restoration project is for it to be self-sustaining.

There is also some risk when excavating in the floodplain that major shifts in the river could capture the channel during a large flood. The presence of the excavated channel might increase that risk. The site assessment and project design should evaluate this risk and accommodate it. Separation of the constructed channel from the river channel will reduce risk of avulsion. Constrictions made of boulders and/or debris within a constructed side channel can control how much flow it can pass and therefore the risk of avulsion. Constructed spillways in areas where floodwaters will enter the channel can help lessen the risk of headcuts forming at those places. See the techniques on floodplain roughness, floodplain drop structures, flow spreaders, and buffer management for ideas that can supplement channel construction to manage risk.

Techniques that require groundwater, while proven successful, do rely on the assumption that a consistent and reliable source of groundwater is available. Appropriate site assessment as described in the following sections can minimize that uncertainty. Changes in land use should be kept in mind as they may alter groundwater dynamics.

1.4 Data Collection and Assessment

Data collection and assessment needs are variable and contingent on the intent of the project, the nature of the channel, and the modifications to be implemented. Data collection and assessment must allow for careful consideration and analysis of the full range of potential impacts and effects. Field data collection should include the following at a minimum:

- Topography of project area and adjacent reaches, including floodplain
- Survey of plan, profile, and cross-sections of existing reach, adjacent reach, and reference reach
- Availability of spawning gravels within side channel
- Documentation of site constraints and project limits
- Evaluation of existing habitat value
- Photo documentation of site from permanent benchmarks that will not be disturbed by the project

Characterization of hydrologic, hydraulic, and sediment transport conditions should include:

- Determination flood discharges and stage within main channel
- Assessment of groundwater availability / potential
- Flood and overbank flow profiles of existing hydrologic conditions
- Hydraulics; including velocity, shear, and scour along the channel

1.5 Methods and Design

1.5.1 Pre-Design

The following pre-design components are important to the development of successful side channel or off-channel projects. These components are relevant to restoration, enhancement, and creation of habitats in these areas.

1.5.1.1 <u>Site Selection and Inventory</u>

The candidate site might be selected from an inventory of potential opportunities. Such an inventory should be conducted as part of watershed restoration planning or flood hazard management planning. Potential sites should be identified from aerial photos and USGS quad maps. Potential sites can be confirmed by conducting a field survey of abandoned side channels or identifying any swales or depressions within the floodplain that are protected from frequent river flooding but appear to be deep enough to be near groundwater.

The following describes the minimum effort required for an assessment of side and off-channel habitat opportunities.

1.5.1.2 Survey

The physical survey should identify and characterize nearby surface water sources. Data should include a survey of river water surface elevations upstream, adjacent to, and downstream of the proposed channel site. The elevations of any surface water within the project area should be recorded. Recent high water marks should be recorded and an estimate the return period should be generated based on past records. Elevation reference points should be set at three locations, and tied together in a survey that includes elevation reference points for other fieldwork on the project site. For off-channel rearing ponds above the river flood plain, measurements of the proposed pond elevation relative to the access channel should to taken to determine the type and magnitude of channel modifications necessary to ensure fish passage.

1.5.1.3 Evaluate Percolation Capabilities

The amount of percolation flow may determine the success of the project. An evaluation of soil characteristics and percolation capabilities is required. Test pits should be dug and percolation tests performed to determine soils, the potential of groundwater flow, and water temperature and quality. Descriptions of the soils should be recorded and a survey of the elevation of soil strata in the test pits conducted.

Pump tests may be necessary to more accurately predict percolation rates. Analytical hydrologic methods are not available for spring flows; therefore, direct flow measurements should be made for a period of a year. A flow measuring weir can be installed but be aware that a slight change in water surface elevation can significantly change the volume of measured flow.

To accurately quantify groundwater-flow potential, an extensive aquifer test with at least several high-capacity wells and a long period, high-capacity pump test would be required. Such a test is not practical for this scale of project. A suggested alternative is to use parameters that indicate the relative potential among sites.

The Washington Department of Fish and Wildlife has developed a simple pump-test method[5]. This pump test procedure simplifies the description of the groundwater by making the assumption that the aquifer has no impermeable boundaries. This method calculates relative aquifer permeability and relative aquifer supply rates.

Water is pumped from a test pit excavated by backhoe. Two parameters are used to analyze the groundwater potential: drawdown index and apparent velocity. The drawdown index is the pump rate divided by the drawdown rate, and the apparent velocity is the pump rate divided by the wetted area of the test pit. These parameters have been measured for 12 different projects, and comparative ratings have been developed.[5] Piezometers should be installed in the test pits and at additional sites along the proposed channel alignment.

1.5.1.4 Water Supply

River and groundwater levels and/or flows should be monitored during a wide range of river flows (at least three per monitoring site) and seasons. This usually requires a period of one year to cover winter and summer groundwater levels. These measurements can then be used to determine channel-control elevations, the depth of excavation and the potential of backwater effects from the river downstream.

For groundwater fed channels, the design of the channel elevation requires balancing the optimum water surface elevation for maximum groundwater flow against the potential that the channel will be backwatered too frequently from the river mainstem. Percolation flow, and therefore upwelling intergravel flow, is reduced when the channel is backwatered. The channel should operate most of the time without backwater effects from the river unless strong upwelling is expected to continue. The channel should be designed to not lose surface flow during summer months.

A spawning channel needs a reliable source of water during the spawning and incubation periods. A hydraulic gradient is created when a channel or pond that is excavated into the water table with the channel outlet and water level control elevation below the static water level. This hydraulic gradient controls the amount of surface water flow and is an important parameter in the success of a project. The gradient and surface area has much more influence than does the depth. The amount of flow can be a controlling factor for adult usage and juvenile recruitment. Furthermore, the amount of inter-gravel flow is also closely related to egg-to-fry survival.[6] The quantity of groundwater flow is important, so it is desirable to make pre-project estimates of the flow potential.[7]

1.5.2 Created Physical Habitat Elements

For rearing, structures should be located throughout the channel to provide juvenile and adult fish with cover from predators and refuge from high velocities. Intermittent deep pools should be provided with cover for juvenile rearing and adult holding. Riparian structure should be built into the banks of the channel.

For spawning, adhering to velocity, depth, and substrate criteria typically results in a channel with a gradient of .2% to .6%. Local physical constraints typically dictate the overall alignment of the channel that may incorporate other fisheries habitat considerations such as rearing ponds, holding areas, and the presence of adequate cover. Artificial channels often incorporate a settling basin for fine sediments at the head of the channel.

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Features such as spawning gravel should be incorporated into the design. Exposed gravel in the channel may be used or processed material may be imported into the site. Many channels have provided successful spawning habitat using existing substrate. An evaluation of the presence and quantity of potential spawning gravel can be conducted during excavation of the initial project test pits. It may be economically viable to screen gravel from the overburden for use as spawning bed material. Appropriately sized gravel is critical to the success of a groundwater fed spawning channel. Rounded rock provides ideal spawning habitat for many salmonids. For most species, the general guideline is approximately 80% of 10 to 50 mm gravel with the remaining 20% made up of 100 mm gravel and a small portion of coarse sand (2 to 5 mm).
Angular or crushed gravels should never be imported to use as spawning substrate.

If the channel sub-base material is sandy or clayey, a gravel filter or geotextile blanket is often required to support imported spawning gravel. Additionally, special low bearing pressure equipment may have to be used for at least part of the excavation. During construction of the channel, a layer of sand will likely accumulate on the gravel bed. It may have to be cleaned with a gravel-cleaning machine. Any debris should be anchored to accommodate large fluctuations in river water levels that backwater the channel.

1.5.2.1 Spawning Pads

Spawning pads are a means of increasing the availability of spawning habitat in an existing channel. Spawning pads are created by either building a channel constriction or a drop structure across the channel, then placing a specified mix of spawning gravel upstream and/or downstream of the structure or allowing native gravel to distribute and deposit during high flows. Either structure creates a backwater upstream and a pool and tailout downstream that can collect gravel. The upstream gravel placement can also be designed to feed gravel to the tailout area. The channel constriction can create more diversity and intra-gravel flow than a cross-channel weir. It also has a much lower risk of creating a fish-passage barrier.

Spawning pads might be necessary where natural, woody debris has been removed, and no structure exists within the stream channel to retain gravel in stable bars. They are usually built as a series of drop structures. Once the design elevation is selected at the upstream end of the channel, the gradient of the channel can be selected. Spacing between structures is based on channel gradient and the maximum allowable height of drop at each structure. The drop should be 0.80 foot or less during all flows occurring during periods of fish migration to facilitate fish passage (according to WAC_____). If upstream juvenile fish passage is necessary, the drop required may be as small as six inches.

Structures with small drops are not as effective at sorting downstream gravel. In addition, the lower hydraulic head results in less intra-gravel flow. Since the structures are built in a porous bed, it is often difficult to maintain flow over a water control structure that is higher. Water level controls such as log weirs need to be sealed with an impervious geotextile material to prevent loss of flow over the control and loss of fish passage there.

A potential risk with spawning pads is that spawners are often attracted to the newly placed gravel before it has had a chance to distribute hydraulically and stabilize. The eggs may not survive if the gravel in the spawning pad shifts during the first flood flows. Where possible, fish use should be discouraged until the substrate has settled.

Channel constrictions can be used effectively to create spawning pads, but they should be considered only with a clear understanding of the dynamics of channel instability. Constrictions, as described elsewhere in these guidelines, can create a backwater condition resulting in gravel deposition and, ultimately, leading to channel reconfiguration, a situation that creates spawning habitat but can jeopardize bank stability. These dynamic processes are what naturally create spawning habitat. Constriction spawning pads usually only constrict the flow at moderate flood levels when gravel sorting occurs. They are generally constructed as low structures that will not constrict the channel during large floods.

A channel constriction is more effective in low-gradient, spring-fed channels than a full-spanning structure. A channel constriction should be designed to increase velocities enough to keep fine sediment flushed out of gravels, maintain a tailout, and be attractive to spawners. Probably need to watch that series of these does not cause channel degradation. Spawning may occur in the constriction or at the tailout area. The spacing of constrictors is based on the channel gradient and the degree of backwatering developed by the constrictor. A common mistake is to place constrictors too close together, resulting in the backwatering of the upper constrictor, which, in turn reduces velocities through the upstream constriction, thereby negating the intent of the application. Constriction design, including spacing and size, can be accomplished using either hydraulic models or through trial and error in the field.

An advantage of porous weirs and drop structures in creating spawning habitat is the high intra-gravel flow developed through the structure and bed upstream. However, this can be a problem if the stream experiences very low flow, and the entire flow goes subsurface. The standard, log drop structure technique developed by the Washington Department of Fish and Wildlife is a good solution that has been effective and durable in many Washington streams over the last 15 years.[9]

Placeholder: need to discuss gravel size and distribution and depth. Some of this is covered in other spawning techniques. Summarize info that is available elsewhere, and refer to other techniques for relevant information.

Placeholder : Provide design guidance on drop structures and constrictors (e.g, material, shape, how far should they be embedded…).

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Constructing rigid weirs and channel constrictions in a channel creates a long-term monitoring and maintenance issue and may limit migration and natural evolution of channel.

1.5.2.2 Artificial Spawning Channels

Artificial spawning channels are intended to provide a highly regulated and controlled spawning environment. Channels are designed to provide for counting of adults into area, dewatering for maintenance and fry removal, screening at upper end for predator control; and settling basins for silt removal. Bell (1991) presents the following criteria regarding general design limits for artificial spawning channels.

- Widths – 12 to 40 feet
- Lengths – general lengths of bed segments: up to 1,000 feet with a control for each segment.
- Bank Shear Stress – use 5 feet per second for bank protection design.
- Gravels: spawning bed: 80% (0.5 to 2.0 inches), 20% (up to 4 inches)
- Under spawning bed: 3 inch plus (2 feet deep)
- Hydraulic Criteria:
    - Velocity average = 1.5 feet per second
    - Depth = 1.5 feet during spawning times
    - Slope = 0.0006
    - Roughness = n = 0.025-0.030
    - Percolation rate = 1,100 mm/hr
    - Spawning flows = 2.25 cfs per foot of mean width
    - Incubation Flows = greater than or equal to 1.5 cfs per foot of mean width
    - Fry removal flows = 3.0 + cfs per foot of mean width

1.6 Project Implementation

1.6.1 Permitting

Permitting channel modification projects will be very site- and project-specific. Channel modification invariably involves physical disturbance of the channel, which disrupts habitat and water quality at the site and downstream. A general discussion of permitting requirements is included in the introduction to Chapter 5 of this document.

1.6.2 Construction

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Off-channel habitat is usually constructed out of the active river channel and therefore requires less attention to factors that complicate construction in sites with moving water. If a channel is to be constructed in a surface water channel or in a spring channel with substantial flow, a thorough plan for project sequencing and care of the water must be developed. It might include temporary closure berms to isolate work areas, pumping water onto the forest floor or settling basins, and substantial filter devices to clean water that will discharge to the main river. Factors such as access, materials availability, equipment and labor, and sediment control are must be considered. Further discussion of these elements is provided in the Construction Appendix.

1.6.3 Timing Considerations

Timing considerations are less of an issue in the establishment of off-channel habitat because the projects are usually somewhat removed from nearby bodies of water. Construction should be conducted when potential impacts to migrating or spawning fish are minimized. Additionally, construction should occur during seasons of low groundwater levels.

1.6.4 Cost Estimation

Cost is highly variable in spawning and rearing enhancement projects. Location of spoil piles, availability and delivery of gravel and large, woody debris, and site access are the primary factors that result in variable costs. One option used by the Washington Department of Fish and Wildlife to obtain spawning substrate is to sort gravels near the site. This technique involves the use of a mobile sorting operation located within close proximity to the project site. This technique significantly reduces delivery costs. Using on-site materials, construction costs may range from as little as $6 to $8 per cubic yard of material excavated, which includes bed controls, habitat structures and revegetation. However, imported gravel may cost $40 to $60 per cubic yard installed

1.6.5 Monitoring and Tracking

Biological monitoring provides the ultimate measure of project success. Annual spawner counts and redd surveys are the most direct measures of spawning utilization. Trapping of juvenile fish entering and leaving a site may be used to evaluate the rearing use of a channel. For a comprehensive review of habitat monitoring protocols, see *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest – Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia*.[8]

In addition to biological monitoring, the monitoring of physical conditions is important to the documentation of project success. Periodic flow measurements in the channel will determine whether the flow is constant or diminishes over time. Analysis of sediment in the gravel bed can be used to evaluate its quality over time. An evaluation of headcut-prevention measures should be done after large floods occur that are high enough to enter the channel.

1.6.6 Contracting Considerations

Refer to contracting considerations section of the Construction Appendix.

1.7 Operations and Maintenance

Maintenance is minimal with this type of project, although fine sediment and organic debris may gradually accumulate in the gravel bed. Periodic cleaning of gravel and/or supplementation with new gravel may be required to maintain or restore full habitat potential.

1.8 Examples

The Washington Department of Fish and Wildlife has constructed a number of groundwater channels in recent years. Good example projects that incorporate the latest design information include Young's Slough, Nolan Channel, and Peterson Pond on the Hoh River in Jefferson County; Rainier Channel on the Bogachiel River in Jefferson County; and Taylor Channel, Park Slough, Illabot Slough and Park Slough Extension on the Skagit River in Skagit County.

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1.10 Photo and Drawing File Names

No photos
Figure 6-2 from ISPG: Spawning and Rearing Conceptual Design – channel.jpg